Clutter Environment Analysis using Adaptive Processing: The CLEAN-AP Filter

A. Non-Confidential Description

Weather radar backscatter from the ground (or fixed targets on the ground), known as ground clutter, can contaminate weather signals, often resulting in severely biased meteorological estimates. If not removed from the estimate, the ground clutter contamination tends to bias reflectivity high as well as radial Doppler velocity and Doppler velocity spectrum width toward zero. A ground clutter filter (GCF) can mitigate this contamination and provide unbiased meteorological estimates but typically with reduced quality. Moreover, significant biases could result if the GCF is applied when ground clutter is not present and the weather signal has near-zero Doppler velocities. Thus, the overall quality of the meteorological estimates needlessly suffers when a GCF is misapplied (i.e., either not applied where there is contamination or applied where there is no contamination).

The problem of applying the GCF becomes very complex. Typically, weather radars use static clutter maps (i.e., pre-identified clutter contaminated regions) to control the application of the GCF. However, anomalous-propagation conditions can cause the radar beam to increase contact or overshoot ground clutter, giving the appearance that the clutter shifts within or disappears from the radar volume coverage very rapidly. This constant shift of the ground clutter in the radar volume coverage renders static clutter maps ineffective for controlling the application of the GCF in a dynamic atmosphere.

Fortunately, spectral examination of the received echoes provides a means to determine the presence of ground clutter in real time without having to rely on static clutter maps. A disadvantage of using spectral analysis on a finite number of samples comes from spectral leakage; hence, tapered windows are typically applied to contain this detrimental effect. It is desirable to use low dynamic range windows to preserve the quality and resolution of the meteorological estimates. However, high dynamic ranges windows may be required to adequately suppress strong ground clutter returns, consequently reducing the quality of the meteorological estimates.

A spectral GCF capable of mitigating the adverse effects of ground clutter while preserving the quality of the meteorological estimates is provided here. This ‘smart’ filter performs real-time detection and suppression of ground clutter returns in dynamic atmospheric environments and is named: Clutter Environment ANalysis using Adaptive Processing (CLEAN-AP).

B. Advantages and Improvements over Existing Practices

Compared to current technologies used for ground clutter suppression, the CLEAN-AP filter provides a real-time, integrated clutter mitigation solution with: (a) improved ground clutter suppression, (b) effective ground clutter detection, and (c) dynamic ground clutter suppression characteristics optimally matched to the existing atmospheric environment. All of this is achieved with modest computational complexity and increased quality of meteorological estimates.

C. New Features

Unique to this invention are: (a) the use of correlation spectral densities for clutter detection and suppression, and (b) the method of adaptive windowing to change the clutter suppression characteristics of the ground clutter filter to optimally match the ground clutter environment.